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ABSTRACT

This paper reviews press coverage of events surrounding the 1977 governmental decision to ban fluorocarbons in spray cans in the United States. The research reported focused on the years 1972 to 1978 and involved a count of the number of items published in selected newspapers and magazines or aired on the three major networks' evening news broadcasts. The paper notes how fully the mass media informed the public of the controversy concerning fluorocarbons, examines whether the media presented scientific details about the issue clearly, and reports whether they placed the issue in a context that helped build a foundation for public understanding of more basic issues such as the quality of regulatory action and the diversity of philosophies underlying environmental conflicts. The paper also points out instances in which the mores and structure of journalism (as well as those of science and government) influenced media reports. Appendixes contain a list of the periodicals surveyed and a timetable of events related to fluorocarbon deletion theories. (FI)

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PRESS COVERAGE OF THE FLUOROCARBON CONTROVERSY: THE RISE AND DECLINE OF A 'HOT' SCIENTIFIC ISSUE

by

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Representatives from 14 federal groups met in Washington late in 1976 to contemplate the future of fluorocarbons in spray cans. The question confronting this committee was whether the fluorocarbons, which provide the "oomph" in many spray cans, deplete the layer of ozone in the stratosphere. If the amount of ozone decreases, it might allow more ultraviolet radiation to reach earth, harming plants, animals and humans.

Although aware of their own limited knowledge of fluorocarbons, the bureaucrats recommended that the Environmental Protection Agency, the Food and Drug Administration and the Consumer Product Safety Commission impose a ban on some fluorocarbon uses. Those three agencies followed the advice, announcing a three-step ban that culminated in April, 1979 with a prohibition against using fluorocarbons in nonessential aerosols. Meanwhile the EPA is considering action against other uses of fluorocarbons, and may propose regulations affecting such common items as refrigerators and air conditioners. Despite further scientific research in the area, the agency almost certainly will act again without full knowledge of fluorocarbons' effects.

This study focuses on newspaper and magazine coverage of the fluorocarbon issue from 1972 to 1978.[1] The former appear to remain "the workhorse for conveying most science information to most people,"[2] and the latter are thought to provide the most indepth coverage. Abstracts of ABC, NBC and CBS evening news also were consulted and stories concerning fluorocarbons quantified, but no attempt was made to analyze the complete television broadcasts. (See Appendix A)

The report will note how fully mass media reports informed readers of the controversy concerning fluorocarbons. It will examine not only whether the media presented scientific details about the issue clearly, but also whether they placed the issue in a context that helped build a foundation for public

understanding of more basic issues such as the quality of regulatory action and the diversity of philosophies underlying environmental conflicts. It also will point out instances in which the mores and structure of journalism (as well as science and government) influenced media reports.

The fluorocarbon case is not unique. Decisions to take political action -- or not to act -- in such diverse areas as nuclear waste management, saccharine regulation and employment policy often are preceded by weeks of hearings and documented with mounds of paper, but rarely are they supported by a complete understanding of ramifications. Frequently scientific studies are commissioned to fill the knowledge gap. But, as in the case of the 1970 call to end development of the supersonic transport, perceived urgency may lead to political action even before the research is complete.[3]

Furthermore, such commissioned studies can themselves be ambiguous and controversial. As John Hayes, Indiana University chemistry professor, noted in discussing the SST debates, many scientific findings are qualified. "That's a classic science problem," Hayes said in a speech last year before a group of foreign journalists at Indiana University. "When they're asked finally 'okay, Doc, should we do it or shouldn't we do it,' the answer is 'maybe.'"[4]

Journalists accustomed to writing "one expert says pro, but a second says con," find it hard to deal with scientists who say "perhaps, in some cases." The temptation arises to simplify science articles by leaving out uncertainties or to ignore stories until "the scientists know what they're talking about."

But the resulting lack of coverage may leave media consumers ignorant about issues at the very time they need information -- when public policy decisions are being made. As New York University journalism professor Hillier Krieghbaum states in Science and the Mass Media:

> Unless there is real understanding of science and technology (not necessarily a comprehension of nuts and bolts details and specialization but rather a backdrop of basic knowledge and an intelligent appreciation of goals), our cherished forms of traditional decision-making in a democracy face new and dangerous threats.[5]

As Krieghbaum's statement implies, the coverage needed to inform readers should not merely present a parade of details, but should put information in a context that portrays how and why scientists work, so readers can form a foundation on which to build their response to future scientific issues. Krieghbaum terms this "adult education"; Peter Farago, in Science and the Media, calls it "demythologizing science."[6]

Even if consumers did not need scientific information to participate in decision making, science news would be important. Science and technology pervade our everyday lives increasingly; furthermore, they are an indigenous part of our history. Science is a human adventure, Krieghbaum notes, and Farago points out:

> The ability to manipulate concepts, to form patterns is as much part of the human genius as the ability to express itself through the creation of poetry, painting and music ... It is part of our cultural heritage and an indication of our future; to deny the majority the opportunity to take part in this exploration would be to deprive them of the glory, excitement, and spiritual and intellectual development they have every right to as fellow human beings.[7]

With that understanding of the importance of science reporting, this study will examine press coverage of the debate concerning the use of fluorocarbons, a significant and ongoing issue in which scientific data offered no clear-cut answer to policy makers' question, "should the status quo be changed?" Perhaps this examination of the strengths and weaknesses of fluorocarbon-ozone coverage will bring journalists a step closer to offering readers the information they deserve and need to influence political decision making.

OZONE

The substance that has made fluorocarbons an issue between 1974 and the present is ozone, a molecule made up of three oxygen atoms instead of the two atoms normally found in the oxygen we breath. As German chemist Christian Friedrich Schönbein noted when he discovered ozone, there's not much of it in the atmosphere.[8] As often happens with little things, ozone wasn't paid much attention.

The compound did arouse some interest among scientists late in the nineteenth century for its role in the stratosphere, a then-newly explored region of the atmosphere where temperature goes up instead of down with height. Research showed that ozone helped cause that permanent temperature inversion by giving off heat during the ongoing reaction in which it tumbles from the energized three-atom state to two-atomed oxygen and back again.

But the studies were purely academic until some scientists discovered that trace substances in the stratosphere might be working as catalysts, destroying ozone without being themselves destroyed. Calculations indicated some man-made catalysts might be increasing the rate at which ozone was being destroyed by rising to the stratosphere, thus upsetting the balance set up over many years between ozone and naturally produced substances. Harold Johnston, a chemist at the University of California at Berkeley, and Paul Crutzen, meteorologist at the National Center for Atmospheric Research, determined that one such catalyst might be nitric oxides from supersonic transport exhausts.[9]

In 1970, Crutzen had discovered that much ozone is destroyed by nitrous oxides (sometimes known as laughing gas) released through the decay of such "nitrogen fixing" plants as clover, peas and beans. Because nitrous oxide is fairly inert (it doesn't like to react with other molecules), Crutzen postulated it must rise through the atmosphere to the stratosphere where, in the full glare

of ultraviolet rays, almost nothing is inert. There nitrous oxide could dart about acting as a catalyst, perhaps converting thousands of ozone molecules into ordinary oxygen before wandering back into the lower atmosphere and combining with water vapor. Now Crutzen and Johnston said nitric oxides from SSTs could perform similar ozone-destroying feats.

That theory aroused action among chemists and politicians. Though small in number, ozone molecules play an important role in maintaining life on earth by keeping all but about one percent of the sun's biologically active ultraviolet (UV-B) rays from hitting the earth. Evidence comparing areas such as the tropics that receive a greater percentage of UV-B (because the sun hits those areas more directly, and the ozone shield above them is thinner) with areas nearer the earth's poles indicates UV-B may be an agent in causing skin cancer. Although the case isn't closed, every one percent reduction in ozone, which would cause a two percent increase in UV-B on earth, could increase the incidence of skin cancer up to four percent.[10]

Scientists say humans may not be alone in their vulnerability to increased ultraviolet radiation. Plants bombarded with extra UV-B show mutations, reduced photosynthesis and unnatural growth and development. Lower forms of life, especially the phytoplankton growing on the sea's surface, also could suffer. Because phytoplankton are the basis of the aquatic food chain and produce a significant amount of oxygen through photosynthesis, their plight likely would have a wide-ranging effect on the ecosystem.

Besides limiting the penetration of ultra-violet radiation, ozone may influence the earth's climate, although evidence here is even more sketchy than that for ultra-violet radiation effects. Changes in the ozone layer definitely would alter stratospheric climate, but effects on the lower atmosphere haven't been gauged. Scientists fear, however, that a climatic change as small as two degrees could

impact the global food production.

Ironically, this molecule whose stratospheric role is so vital to our existence can harm us when it exists on our level, in the earth's troposphere. Ozone created when pollutants such as nitrogen oxides and hydrocarbons mix in sunlight, being unstable and highly reactive, grabs onto such substances as nylon, rubber and lung tissue. It irritates the lungs and throat at concentrations a low as .07 part ozone per million parts air, often causes nausea and headaches and may bring an increased incidence of skin cancer. Ozone can be especially harmful to persons with respiratory problems, although scientists have not proven that the damage is cumulative or permanent.

Thus, although ozone got its name (the German word for "to smell") because of its pungent odor, it does much more, both to benefit and harm, than tickle the nostrils.

FLUOROCARBONS

Chlorofluorocarbons, or as we'll term them, fluorocarbons, are younger than ozone, but no less bothered by a dichotomy between their positive and negative aspects.

Not that General Motors chemists realized the controversy their finding would bring when they first synthesized dichlorodifluoromethane (F-11) and trichloromonofluoromethane (F-12) in 1928. Working for the company's Frigidaire division, they were assigned to find an inert, nontoxic, nonflammable substitute for such dangerous refrigerants as sulfur dioxide, ammonia and methyl chloride. F-11 and F-12 claim those characteristics. F-12 soon was introduced as a coolant in refrigerators (and later in air conditioners), and in the early 1950s E.I. Du Pont de Nemours (Du Pont) began using F-11 as a propellant in aerosol sprays. Being inert, the fluorocarbons (which Du Pont bought and trade-named Freon) did not react with the spray can or its "active ingredients"; being non-flammable, they could produce a fine mist spray -- as the hairs on many underarms and heads soon could attest.

Robert H. Abplanalp further aided the aerosol spray can industry by inventing a plastic and metal valve that could dispense spray at the touch of a fingertip. He founded a corporation to mass-produce such valves.

In 1954, 188 million spray cans were produced, 100 million of them containing insecticides and shaving creams. Four years later, hair spray led a field of 500 million spray cans, and 10 years after that, in 1968, 2 billion, 300 million aerosol cans entered the world, at least 500 million of them holding hair sprays. Note, however, that not all sprays were propelled by fluorocarbons. Because F-11 is more expensive than such propellants as carbon dioxide (which blobs and drips as the level in the can drops) and hydrocarbons (which are flammable), those gases were used in products that (like insecticides) didn't require a fine spray or (like paint) were themselves flammable.

Fluorocarbons' next claim to fame came in 1970, when free-wheeling British chemist James E. Lovelock looked for and found F-11 in the skies over Ireland. Using an electron capture detector gas chromatograph (ECGC) he had invented, he could measure gases in amounts as minuscule as a few parts per trillion, a feat unmatched by all previous atmospheric measuring devices. In 1971, Lovelock measured samples from shipboard in the North and South Atlantic and again found the gas, in amounts roughly equal, he thought, to the quantities produced since F-11 was invented. He assumed F-12 also was present, since it is even more stable than F-11, though less easy to spot.

Lovelock considered the fluorocarbons a useful and harmless tracer of air movements, and he said so in his published reports. But another scientist, F. Sherwood (Sherry) Rowland, who heard of Lovelock's calculations at a 1972 conference between meteorologists and chemists in Fort Lauderdale, Fla., wasn't satisfied. The gas had to end up somewhere, he thought, and his new post-doctoral researcher, Mario Molina, agreed. Using funds from the Atomic Energy Commission (now the Department of Energy), the two suggested that fluorocarbons must travel upward and after many years -- perhaps 40 to 150 -- enter the stratosphere. There, like the nitric oxides in Crutzen and Johnston's research, the gases could act as catalysts in depleting ozone.

Thus ended fluorocarbons' peaceful existence as gases assumed to be harmless, beneficial and worthy of little media attention. That change, in turn, threatened the peaceful, non-controversial lifestyles led by Rowland, Molina and other chemists who studied fluorocarbon-ozone chemistry. Controversy often brings coverage, in science as in other areas of life. So also with this debate -- but not immediately.

BECOMING 'NEWS'

Rowland and Molina finished their work just before Christmas in 1973, and Rowland wrote the resulting paper while in Vienna for a six-month Guggenheim fellowship. He sent the paper to the British journal Nature, where it was stalled by a vanished referee before being published in June, 1974. Meanwhile, Rowland discussed his work with Paul Crutzen and others familiar with stratospheric research, and Crutzen mentioned Rowland's work during a speech at the Royal Swedish Academy of Science. Swedish newspaper reporter Katrin Hallman wrote a front-page story about Rowland's findings after covering Crutzen's speech. The article did nothing to spark the interest of other science writers, although it did visibly disturb Du Pont, the largest single producer of fluorocarbons (there were 19 producers worldwide, including six in the United States, when the furor arose).[11]

Even after Nature published Rowland's research and the University of California, Rowland's employer, scattered press releases among the science writers of major media outlets, few newspapers and magazines outside of California considered it newsworthy.[12] The Ozone War, an account of the fluorocarbon depletion controversy, notes:

> Several of the major newspapers, including the New York Times and the Washington Post, kept the story at arm's length. Later, the Times' science writer, Walter Sullivan explained why: There was so much "doomsday reporting" going on at the time that he was not particularly anxious to jump too quickly at this latest prediction of environmental disaster.[13]

Sullivan's statement may reflect a desire to rationalize his error after missing the opening of a big story, but his action was a logical outcome of journalistic constraints. As Joel Primack and Frank Von Hippel note in their work Advice and Dissent: Scientists in the Political Arena:

> (M)ost reporters have too little time and know too few sources of information to do serious investigative reporting. As a result, reporters tend to rely largely, if not exclusively, upon "official sources" for such news -- mainly government officials and corporation spokesmen.[14]

That's especially true at the many newspapers which have no full-time science

reporters. But even at the New York Times, which has a staff of science journalists, reporters tend to cover topics they've heard of before, using sources they trust from past experience.

"Information overload" also increases the possibility of missing important news. As Rae Goodell notes in The Visible Scientists:

> The New York Times science department receives enough mail each day to make a stack between one and three feet high, and the deluge at most major newspapers and television networks is similar ... Somehow the reporter must cull from the masses of material a very few stories to write. And he must make his decision in a very short time.[15]

Although Sherry Rowland was a respected scientist, he (like a remarkable number of those involved in ozone research) was working outside of his field. He had specialized in the chemistry of radioactive isotopes, not atmospheric chemistry or meteorology. Thus the combination of his name and stratospheric chemistry did not catch the attention of editors outside his home state. California papers did publish scattered articles, perhaps reflecting concern for pollution and familiarity with ozone (due to California's excess of tropospheric ozone), but also according with the press's habitual affinity for nearby news.

Though stunted, the story of Rowland's work did not die, partly because American Chemical Society news manager Dorothy Smith placed Rowland's work among the twelve top stories at a mid-September ACS meeting in Atlantic City. She arranged a press conference on fluorocarbons, and the wire services covered it, as did ABC-TV.

Had Smith not chosen to highlight Rowland's work, it might have remained unrecognized. Although, as Krieghbaum notes, editors love conferences that produce the timely phrase "said here today,"[17] reporters bombarded with as many as 100 papers a day are forced to ignore much that happens.[18] The result can be what Farago terms "information scatter"[19] in which knowledge important to society is kept by experts due to a failure to publicize it.

The wire service stories about Rowland's research received some play, although they did not appear in the Wall Street Journal, New York Times, Chicago Tribune or the other papers perused for this study. As Lydia Dotto and Harold Schiff point out in The Ozone War, "the story did not really take off until Sept. 26, when the New York Times ran a front-page article by Walter Sullivan."[20] The Chicago Tribune carried its first fluorocarbon-ozone piece on Sept. 29, and Newsweek and Time offered their first in Oct 7 issues. CBS carried a four-minute report Oct. 3. As Dotto and Schiff say, "To the continuing frustration of many newspapers and science writers across the country, a science story often just doesn't become news until Walter Sullivan and the New York Times take notice of it."[21]

Not only did the Chicago Tribune coverage evidence follow-the-leader journalism, but it, more than either of the more national papers surveyed (Wall Street Journal and New York Times) used the breathless "doomsday" terminology of which Sullivan said he was wary. "Is it a time Bomb?" the newspaper asked in headline-sized type, adding in smaller bold face:

> Spray cans won't zap out life directly.... The link they threaten in our delicate chain of life is the thin layer of ozone high in the stratosphere which acts as a protective shield against the dangerous ultra-violet rays from the sun.

And, the article concluded:

> If we are to avoid the ironic calamity of the ancient Romans, who, some scientists suspect, innocently ate and drank themselves into oblivion with lead dishes, we may have to spray less.[22]

As Dotto and Schiff note, "The reporting at this stage leaned toward the lurid." New Times speculated that "aerosols have probably doomed more people than were killed by the atomic bomb dropped on Hiroshima," and the Philadelphia Inquirer contended, "the world will end -- not with a bang, not with a whimper, but with a quiet pfft.... The earth may already have committed partial suicide or at least severe self-mutilation."[23]

Those statements probably reflect journalists' attempts to place fluorocarbons on the public agenda -- to persuade readers that this new issue indeed has down-to-

earth significance despite its stratospheric implications. The resulting sensationalism and oversimplification indicates how such an approach can go wrong. But science journalists often face the reality that if they concentrate on scientific (and related political) events without relaying how those events might affect readers, their audience may miss the significance of the report -- or even miss the report itself. Farago suggests an amalgam of the two extremes,[24] but such a balance is difficult to strike.

Unlike the Chicago Tribune and other outlets which introduced the fluorocarbon issue sensationalistically, Walter Sullivan employed a measured tone. Almost all of his articles took a straight news approach that tended to grow boring but was informative and accurate.

New York Times editorials also differed from those in the Chicago Tribune, though in the opposite direction: Despite the paper's more even-handed approach to the controversy, New York Times editorials were more numerous and more definitely in favor of regulation than those in the Chicago Tribune. Shortly after the Chicago paper declared, "the answer to this theoretical danger lies somewhere between panicking at the warnings and ignoring them,"[25] the New York Times urged:

> Either to continue pouring the commercial spray gas into the air in the hope that it will not prove lethal after all or to plan for a type of war that can expose the entire world to something far worse than nuclear fallout (referring to another postulated ozone depletent, nuclear warfare--CM) -- that is folly. It is comparable to a child skipping through a minefield on the theory that he won't necessarily step on a mine and if he does, it won't necessarily prove fatal.[26]

Although Sullivan's initial fluorocarbon report was factual and informative, it neatly illustrates the media's hunger for new news. The article does not focus on Rowland and Molina's research, published three months earlier. Instead, it highlights the work of scientists at the University of Michigan, including Ralph J. Cicerone, and at Harvard, including Michael B. McElroy and Stephen C. Wofsy. Both groups supplied Sullivan information by telephone about unpublished research. Thus Sullivan in effect "scooped" the journal Science, which was releasing the

Michigan study the very next day (Sept. 27) and planning to publish the Harvard work Feb. 14, 1975.[27] Among journal editors, such pre-publication release is considered to be in ill form.

John Van Horn, a member of the Manufacturing Chemists Association, contends that "a number of people capitalized on the opportunity to get headlines" during the outburst of publication late in 1974. Whatever the impetus, the sensationalism in some newspapers and magazines was, at least to some extent, counterproductive. Even if it convinced readers of the issue's significance, it unnecessarily added a touch of legitimacy to manufacturers' claims that coverage biased the case against their products.[28]

CONTINUED COVERAGE

Unlike some science stories, the fluorocarbon tale did not end with that first flurry of copy. In fact, the volumn of stories did not peak until September 1976, fully two years after the first New York Times article.

The continued media interest in the issue probably reflects the concern and knowledge journalists acquired while reporting three other threats to ozone, from supersonic transports, nuclear weapons and (almost concurrent with fluorocarbons) the space shuttle. Science writers had some conception of stratospheric chemistry, knew that some federal groups considered ozone threats important and had the assurance of sources active in earlier research that scientists such as Rowland, Cicerone and McElroy weren't irresponsible. Furthermore, spray cans had entered environmentalists' list of hazards before, though because of tropospheric rather than stratospheric concerns.

So when science writers became familiar with fluorocarbon information, they realized it did not have to be treated as an entirely new segment in the public's agenda. They could merely juggle the information earlier treated as "threats to ozone, stratosphere" to make room for a new entry. The inter-relationships made the fluorocarbon news more confusing to readers who forgot, for example, that fluorocarbons and ozone act differently down here than they do in the stratosphere and that supersonic transports and spray cans sport diverse as well as similar hazards. But the similarities meant that fluorocarbon research carried a measure of legitimacy it might otherwise have lacked.

The amount of coverage generated by fluorocarbon research also likely reflects how governmental agencies reacted to the work. Unlike the SST and the space shuttle, spray cans were not part of major federal projects. Instead of downplaying the research, as it had early chlorine studies related to the space shuttle, NASA publicly urged cooperative effort, even seeking and getting status as lead research

agency for stratospheric work.[29] During the SST debates, NASA had been bent on keeping a pet project alive. In 1975, it wanted to appear relevant, and spray cans, refrigerators and cancer sounded impressively relevant.

Editors must have realized that relevance too, and recognized the newsworthy status of the big-name companies manufacturing fluorocarbons -- Du Pont, Allied Chemical Corp., Union Carbide Corp., Pennwalt Corp., Kaiser Aluminum & Chemical Corp.. and Racon Inc.

The researchers themselves attracted public attention, a fact that also promoted coverage. Soon after completing his first fluorocarbon work in 1973, Sherry Rowland began advocating an immediate ban on fluorocarbon use. Other scientists followed his lead; some later backed off, deciding that a delay would not unalterably harm the environment (and still others refused to express an opinion concerning a ban, saying that was a political decision), but Rowland continued his crusade at congressional hearings, scientific gatherings, bureaucratic meetings and press conferences. His peers, including industrial representatives, agree Rowland does commendable research. But some, like British scientist James Lovelock, "wish he wouldn't act like a missionary."[30] Rowland, with Cicerone, McElroy and several others, quickly became what Rae Goodell terms "visible scientists." She says of such persons:

> Part of our government-by-crisis, visible scientists are catalysts in the process of converting problems into visible issues. As figureheads, they attract media (who follow public opinion) and politicians (who follow media and public opinion), coalescing public concern and precipitating changes in national priorities.[31]

One way to make a problem visible is to hold public hearings. Obligingly, the House subcommittee on Public Health and Environment began holding hearings in December 1974 on a bill that would have amended the Clean Air Act by calling for a National Academy of Sciences study of the fluorocarbon issue and authorizing the EPA to ban fluorocarbons if research indicated their danger was real. That

and subsequent bills died (until 1977, when an act passed authorizing a major study of the stratosphere). But the hearings allowed the media to catch many of the ozone researchers (and the rest of the "Incredible Stratospheric Traveling Road Show and Debating Society"[32]) en masse and ready to translate their work into terms legislators (and thus perhaps journalists) could understand. Besides that, bureaucratic meetings, press conferences, scientific seminars and laboratory findings followed each other like falling dominoes in 1975 and 1976. (See Appendix B)

Those events received surprisingly little coverage: Except for a report of the 14-agency Task Force on the Inadvertent Modification of the Stratosphere (IMOS), few events were featured in media other than the New York Times. Yet the density of coverage concerning the general issue of fluorocarbons was higher in 1975 than at any time before or since then (See Appendix C), as some newspapers and a large number of magazines published indepth accounts of the debate in mid-1975. Apparently science writers or their editors considered the plethora of activity evidence of a newsworthy issue, even if each discrete event involving fluorocarbons was not newsworthy.

Perhaps the lack of interest in specific occurrences indicates a move, by science reporters at least, away from the event orientation for which the media have been scolded in the past. But the room saved by ignoring events was not automatically allotted to tracking trends. Many magazines offered no coverage of the fluorocarbon debate following the initial 1975 articles, and even Time and Newsweek coverage declined from two reports each in 1976 to one each in 1977 and none in 1978.

The decline is disappointing, for some of the 1975 articles gave quite accurate accounts of the work to date and showed marked improvement over some 1974 writing. The New Yorker, the New York Times magazine and the weekday New York Times were especially successful in putting the debate in the context

of earlier ozone research, indicating other possible sources of ozone depletion (such as nuclear war, supersonic transports and fertilizers) and noting some of the uncertainties inherent in scientific predictions. This despite the fact that some of the articles displayed markedly diverse reactions to the controversy. Progressive asserted in an October report:

> Of all the many environmental issues, the ozone controversy should be one of the easiest to decide, for incalculable environmental harm is being risked for the sake of essentially frivolous household convenience ... as the evidence at hand indicates, when the forces of the marketplace feel seriously threatened, they are apt to pervert any debate that seeks to define (or redefine) ... social objectives.... The environment is too important to leave in the hands of Du Pont.[33]

Just a few months earlier, Fortune had concluded:

> In dealing with the ozone question, it appears that we are lucky: thanks to scientific alertness, we have the grace of time. For the moment, it should be enough to have served notice upon the industries involved that there is good reason for concern. If we avoid hasty legislation, nature or the marketplace may continue to solve the ozone trouble without the usual havoc from clumsy government intervention.[34]

Somewhere between those two poles, a December New York Times magazine article made this upbeat assertion:

> Which group (environmentalists or industry) will win out will probably depend on the work being done now. But one thing is sure -- man's technology may have created the potential mess we're in, but it seems capable of getting us out of it, either through finding alternatives to fluorocarbons or by clarifying the problem so that other solutions may be discovered in time.[35]

Despite the approach taken by publications such as Fortune and the New York Times magazine, the aerosol industry continues to contend that coverage has been anti-industrial. Du Pont public affairs spokesman Richard Ward said in a telephone conversation, "I think there is a tendency on the part of the press to emphasize at times almost the science fiction aspects of a problem. If they get into a reasoned, balanced argument, it tends to get lengthy and complicated -- not the type of thing you read on the train going to work."[36]

To ensure publicity for its own point of view, the industry established the Council on Atmospheric Sciences and the Aerosol Education Bureau, composed of spokesmen who testified at public hearings, churchsuppers, press conferences and other functions. And Du Pont bought space for a series of full-page and double-page advertisements in major newspapers and magazines.

The speakers and advertisements emphasized that Du Pont had begun environmental research on fluorocarbons in 1972, before the controversy had begun;[37] that the industry was spending $3 to $5 million in a three-year research program through its Manufacturing Chemists Association; that the theory of ozone depletion from fluorocarbons was no more than that -- "just a theory" -- and as such shouldn't be considered strong enough to kill an $8 billion industry, especially with the country struggling to recover from a depression.

Journalists obligingly quoted industrial sources -- and wisely, too, for the industry definitely was an important party in the fluorocarbon debate. But most journalists didn't take the important next step of determining where the industrial facts came from. The coverage didn't sketch, for example, how the quoted $8 billion compared to the gross national product, or who and what that amount included. Adding to the need for clarification, some 1975 articles quoted $2 or $3 billion instead of $8 billion as the worth of the industry. The apparent discrepencies likely resulted from taking differing slices of the industrial pie: As Dotto and Schiff note of the numbers quoted by the industry:

> These figures included the cost of the containers -- not only spray cans, but also refrigerators, freezers and air conditioners. The value of the fluorocarbons themselves was much less. The employment figures are also a bit of a numbers game ... the figure of 200,000 or more put out for public consumption must have included not only those who produced the cans and the refrigerating appliances, but also probably those who sold them as well and anyone else who had anything to do with them.[38]

Furthermore, when industrial spokesmen implied that all of their employees would

lose their jobs if fluorocarbons were banned, reporters failed to note that substitutes such as those already on store shelves would keep the industry alive -- and healthy. Many alternative propellants cost less than fluorocarbons, so packagers could pay for development costs merely by keeping the price stable. Most media consumers had no access to those details.

Science writers also failed to point out that industrial calls for a two-year delay in regulation while research projects were completed remained constant as the years passed, from 1974 to 1978. Though that point may seem small, delay is, as Primack and Von Hippel note, "the most effective weapon in the arsenal of the defenders of the status quo" because politicians (like journalists and media consumers) have short attention spans.[39]

Neither did many media outlets consider the Du Pont advertisements worthy of comment, perhaps reflecting the often commendable division between advertising and news staffs on many publications. An exception to that silence was the Progressive, which did not carry the Du Pont advertisements and felt free to note:

> (T)he advertisement seriously misrepresents some of the key technical and political issues involved. It misleads with regard to the present state of relevant scientific knowledge, it obscures the degree of consensus on this matter which exists outside industrial circles, and it distorts the criteria which policy-makers should use to assess the economic impact of regulatory legislation.[40]

Scientist Sherry Rowland also took issue with the second of Du Pont's advertisements, noting that his original work did not overstate the impact of fluorocarbons "by 300%" as the ad maintained. In a letter to the Science editor published Dec. 12, 1975, Rowland pointed out that "current assessment of ozone depletion by models falls within the range of our original estimates made in August 1974."[41]

No law requires science journalists to clear up the confusion created by advertisers, but if such advertisements are read, then the audience likely was confused by the discrepencies between those advertisements and the news columns. Reporters .

wishing to clarify issues for their audience should deal with that confusion.

Industrial advertisements were not alone in providing potential for confusion in the fluorocarbon debate. The research itself, spurred by scientific concern and federal and industrial funds, included complexities and uncertainties that were difficult for science writers to explain to harried readers in a limited time and space.

In mid-1976, for example, several refinements in the theory indicated fluorocarbons may be significantly less capable of depleting ozone than had been calculated. Rowland announced that chlorine nitrate, a compound formed through a reaction between chlorine monoxide and nitrogen dioxide, was much more stable than had been assumed. Noting this, other scientists hurriedly began studying whether the combination of supersonic transports (which produce nitric oxides) and fluorocarbons (which produce oxides of chlorine) might increase rather than decrease the amount of ozone in the stratosphere. By reacting together, scientists postulated, chlorine monoxide and nitrogen dioxide might keep each other too busy to search out and destroy ozone.

Further study of the rate of reactions showed chlorine nitrate to be less important than some had assumed. But the chlorine nitrate research, plus unexpectedly low measurements of hydrochloric acid[42] brought considerable consternation to members of the National Academy of Sciences who were planning to release a report that bureaucrats (and the media) had hyped as a definitive account of knowledge about the fluorocarbon issue.

Despite orders not to discuss the Academy's conclusions with the press, committee member Hans Panofsky, a Penn State chemistry professor, told Joel Shurkin on March 18, 1976 that the Academy might suggest selective bans on "nonessential" uses of fluorocarbons. The resulting story sent other reporters knocking on the Academy's door, only to be told "new information" might change the outcome. Meanwhile, Academy administrators tried to stop the leak, but were unsuccessful,

as indicated by a Newsweek report that said, "The ax that has hovered over the $500 million fluorocarbon industry seems ready to deliver its deathblow."[43]

The Academy findings, scheduled for completion in April 1976, finally were released in September. They received widespread media attention, both because of the importance accorded them by bureaucrats and because of the prestige given to any work backed by the Academy. All three networks covered the press conference at which the results were announced, as did Newsweek, Time and all of the newspapers perused for this study.

The media focused on only one of two reports released at that gathering, however, a study made by the Committee on Impacts of Stratospheric Change which recommended what action the government should take. The second report, a review of the scientific research by a panel of scientists, was ignored by everyone but Harold M. Schmeck Jr. of the New York Times. And Schmeck merely mentioned the review at the end of his article, noting: "Two reports were made public today by the Academy. One was from the full committee, the other from its panel on atmospheric chemistry. They will be available in about a month."[44] The panel's report perhaps was largely ignored because it was longer, more technical and less geared to immediate action than the committee's version.

The Academy committee's report -- the one on which science writers focused -- was, in Nature's words, "finely balanced." Or, as Chemical and Engineering News put it, "Waffling." The late-breaking research findings had convinced the committee members to back off from a "ban now" approach, but the group didn't want talk of regulation dropped entirely. As the report itself noted:

> All the evidence that we examined indicates that the long-term release of F-11 and F-12 at present rates will cause ... the ozone to decrease steadily until a probable reduction of about 6-7.5% is reached, with an uncertainty range of at least 2-20%, using what are roughly believed to be 95% confidence limits. The time required to attain half of this steady-state value (3-3.75% would be 40-50 years.[45]

Faced with those numbers, but realizing the uncertainty of the evidence, the committee adopted a compromise perspective, asserting that "regulation is almost certain to be necessary at some time and to some degree of completeness," but adding, "Neither the needed timing nor the needed severity can be reasonably specified today." The committee recommended against immediate regulation, saying a delay of up to two years would be tolerable.

Such decisive indecision led to various emphases in reporting, and that variety, in turn, resulted in headlines with nearly opposite meanings. The New York Times, for example, headed its page-one coverage with "Scientists Back New Aerosol Curbs to Protect Ozone in Environment," but the Washington Post declared, "Aerosol Ban Opposed by Science Unit." In this, as other science coverage, a harried reader scanning headlines could reach opposite conclusions even though both newspapers offered possible interpretations of the report.

The EPA, FDA and Consumer Product Safety Commission, having publicly committed themselves to act if the Academy's review indicated fluorocarbons might be dangerous, and responding to the concerns of environmental groups (the Natural Resources Defense Commission, for example, had entered periodic petitions for a ban since late 1974), moved toward regulatory action soon after the release of the Academy study. Industrial spokesmen protested that the agencies were ignoring the Academy's call for a two-year delay. But what the Academy committee hadn't noted -- and only one New York Times editorial pointed out -- was that the very process of instituting regulations would take two years. Waiting two years to begin regulatory action, therefore, would involve releasing fluorocarbons into the atmosphere for at least four years.

In May 1977 the EPA, FDA and CPSC announced plans to jointly ban all nonessential uses of fluorocarbons in aerosols. That announcement brought another round of

media attention, but the resulting articles were neither as extensive nor as numerous as the coverage of the June 1975 announcement of the 14-agency task force findings and the September 1976 release of the Academy reports. The peak of media interest had passed.

WHY NOW PASSE?

Media awareness of actions involving fluorocarbons has continued to decrease. None of the magazines studied published update articles in 1977 or 1978, and newspaper coverage has been sparse. On March 15, 1978, when EPA, FDA and CPSC finalized the ban on nonessential uses of fluorocarbons, neither television evening news nor magazines made mention of the plan for a three-setp phase-out. Oct. 15, the date fluorocarbon manufacturers were to quit producing fluorocarbons for nonessential aerosols, went almost totally unnoticed. The same was true for Dec. 15, when all packagers of nonessential aerosols were to quit using fluorocarbons as propellants; and April 15, 1979, when all interstate shipping of nonessential aerosol products propelled by fluorocarbons was to stop.

National and international meetings are being held to coordinate further regulatory efforts, and the EPA has commissioned two studies related to fluorocarbons, both due in 1979. One of the studies, being done by Rand Corp., will estimate the economic impact of regulating such fluorocarbon uses as refrigerators, air conditioners, direct freezing, solvents and sterilizing and degreasing compounds; the second, assigned to the National Academy of Sciences, will review the progress in scientific research on ozone. A January 1978 Wall Street Journal article stands almost alone in noting the significance the resulting EPA action could have.

Similarly uncovered is the recent laboratory research, through which scientists are not only seeking to refine knowledge about the effects of fluorocarbons on

ozone (using in situ measurements, laboratory experiments and theoretical calculations), but are inspecting other substances suspected of depleting that stratospheric layer. As University of Arizona professor Donald Hunten noted during a telephone conversation, "It's rather curious that the chemists in the labs are hammering out a number of rates for the chemical reactions that have importance for the ozone layer -- and the conclusions that were thought important are starting to oscillate again."[46] Recent measurements, for example, indicate that supersonic transports likely have little negative impact on ozone, and may even create ozone at some altitudes, while the effects of fluorocarbons may be almost twice what late 1976 calculations indicated. If so, fluorocarbons could cause a 12 to 18 percent depletion of ozone in the stratosphere.[47]

Industrial scientists also have continued their research, seeking alternatives to fluorocarbons as well as joining in the more basic fluorocarbon study. Earlier media coverage indicated that F-22, a less inert fluorocarbon than F-11 and F-12, might be a possible substitute in many products. But, said Du Pont public affairs representative Richard Ward in a telephone interview, "When we started to look at it in toxicity tests, we got weak results, meaning we must do long-term screening," which takes about three years.

Other currently used alternatives are less desirable than fluorocarbons. Hydrocarbons such as isobutane and propane, for example, are flammable. Although Ward said there is "no evidence now that they constitute an unreasonable consumer hazard," he acknowledged that "It is a concern for the companies making it, and in the warehouses -- there's a potential for accidents with that large number of flammable gases in one place."[48] Some media outlets mentioned the deficiencies of alternatives in reports made before the ban was announced, but none have studied their track record now that most companies have switched to propellants other than fluorocarbons.

Herb Wiser, principal science adviser in the office of Research and Development of the EPA, summarized the media attention to recent developments in the fluorocarbon debate during a telephone conversation: "Coverage? There hasn't been any.... There was about one and a half years ago, but lately it has been sort of a dying issue."[49]

Why have the media lost interest in the issue? Not because depletion theories are any less significant: Estimates of ozone loss are greater now than they were during mid-1976, at the height of the coverage.

Wiser suggested one reason for the change: "All the hearings were held last year (not quite the case, but most of the study reports came out then -- CM). Somebody would testify, and his statements would be quoted." Though as we noted before science writers don't necessarily focus on specific events, the convergence of numerous events may spark interest in an issue. The lack of publicly announced events thus may be an important reason for the sharp decline in coverage.

Other reasons might include journalists' perception of a decline in readers' interest in environmental doom talk, partly because the sources of that doom have multiplied until each culprit gets lost in the crowd. Also, the continuing fluctuation in depletion estimates may be leading journalists to take a "wait it out" attitude.

Whatever the reasons, the decline correlates with the finding of William R. Oates, who studied coverage of Dr. Christian Bernard's first heart transplant in 1967. Oates discovered "a quick drop-off in coverage and almost no indepth consideration of social and ethical implications."[50] The decline also supports Farago's contention that "news about science reaches the general public in waves rather than in a steady stream: a topic might be described, discussed, and argued editorially only to disappear suddenly from the pages of the newspapers."

What is the result of the uneven diet? Farago says, "During the discussion period the public might be bombarded with conflicting information and advice....

What is undoubtedly lacking is a sustained flow of information that would allow aspects of science to become part of the general consciousness."[51]

A steady diet of science news would not in itself create that consciousness. As John Troan, then-science writer for the Scripps-Howard Newspaper Alliance, stated in Science, "To do any good, a story must capture the reader's interest and sustain that interest. In other words, it must be interesting as well as informative, entertaining as well as educational."[52] Some of the fluorocarbon news was written entertainingly, but science writers did not make full use of several means of enticing readers into their articles.

One device available is the use of metaphors, similes and other characterizations to help readers visualize scientific concepts. At times journalists writing about fluorocarbons quoted scientists who used that technique.[53] But they didn't often venture to invent their own ideas. That's unfortunate because, as Krieghbaum notes (using a simile), "Just as lawyers have their terminology, so scientists have a vocabulary of their own.... Despite a rise in science literacy since World War II, a public's knowledge still falls far behind the specialist's as he discloses his recent experiments on a scientific frontier."[54] Imagery could help bridge that gap.

Secondly, many of the newspapers and magazines failed to put their artists to work. The Chicago Tribune standardly used a diagram showing the layers of the atmosphere;[55] others used photographs or drawings of spray cans (angering industrial spokesmen, who reminded the media that even in 1974 only 50 percent of the aerosols were propelled by fluorocarbons); but few illustrations charted the steps occurring in ozone depletion. In critiquing the coverage of the fluorocarbon debate, John Hayes noted:

> We could have had a few little maps, a few little cutaway diagrams of the earth's atmosphere showing a freon molecule wending its way up to the stratosphere, an arrow next to it that said 30 years is the average time required for a gas molecule released at the earth's surface to reach a height of 50 kilometers in the earth's atmosphere.[56]

That's one scientist's vision. An artist and a science writer could create much more.

Science writers also could have wooed their audience and given a flavor of scientific culture by portraying scientists as people. Hayes inadvertently illustrated the possibilities of that appraoch while chatting about the inventor of the electron capture detector gas chromatograph, James Lovelock. "Lovelock could sell, I think, a used rug to an Arab. He would not brook any criticism of his research. When he was asked questions in scientific meetings, he would say, 'I'm sorry, but if you haven't read my papers...' His little detector worked, but not the way he said it did."[57]

Dotto and Schiff indicate Lovelock was not the only unique scientist involved in the fluorocarbon research. Speaking of Harvard's Michael McElroy, for example, the authors say:

> Mike McElroy is one of the most flamboyant personalities associated with the ozone controversy. He is known for the quickness of his mind and his facile ability to assimilate and understand new ideas and information rapidly; it is a talent that disconcerts colleagues and competitors alike ... McElroy, an Irishman with a shock of red hair and a pale complexion, can be a walking advertisement for the effects of ultraviolet radiation (UV-B seems to cause skin cancer in light complected persons more readily than in those with darker skin -- CM)[58]

The gathering of men as headstrong and competitive as McElroy turned at least one American Chemical Society session into a "cozy gathering of hate" in which new calculations and measurements were unveiled and heatedly debated.[59] Some observers attributed the tense pace of fluorocarbon research and the doomsday statements made by some scientists to "the smell of a Nobel prize."

As those examples indicate, weaving the personalities and mores of scientists into some science reports would help readers understand the highly human and uncertain nature of the work done by those folks who too often are regarded as totally objective, emotionless scholars. True, focusing on scientists may create a danger of echoing campaign coverage, with its attention to personalities at the

expense of issues. But as Rae Goodell notes:

> In the case of visible scientists ... there are some counterbalances (to celebrity charisma). As outsiders, visible scientists are often battling against strong cultural traditions, entrenched government policies, major industrial interests. They are Davids to institutional Goliaths. And one of the Goliaths is the scientific community itself.... The visible scientists reject the control of the scientific community, and offer a different view of science.... They resurrect for public view the intuitive side of scientific discovery and the subjective side of scientists.[60]

Including references to the humanness of scientists, then, could both entertain and inform. Like other techniques for enticing an audience, this could lead to a greater interest in and awareness of scientific findings.

CONCLUDING THOUGHTS

The media did a credible job of informing the public that scientific findings had raised some controversy about spray cans. By late 1976, according to a survey conducted by De Vries and Associates, Inc. for the Consumer Product Safety Commission, 73.5 percent of the American public had heard something about the issue, often through the media (primarily newspapers). Some respondents expressed total confusion about the debate, saying they believed their underarm deodorant spray contained the harmful chemical ozone which could produce skin cancer. But many had at least a vague idea of the issues involved.[61]

Besides providing the basic and immediate facts, however, the media should strive to put scientific issues in context and thus prepare readers for upcoming variations on current themes. In a narrow sense, as we have noted, some outlets did this during 1975 and 1976. But even most of the best articles neglected some important aspects of the fluorocarbon problem. The extent of international cooperation in what must be a global problem was rarely noted, for example. Neither was much attention paid to uses of fluorocarbons outside of spray cans --

or to the relative importance of those uses. And science writers, even in Chicago where tropospheric ozone pollution led to numerous summer ozone alerts, gave readers little help in distinguishing the difference between ozone's beneficial role in the stratosphere and its unwelcome presence here below. Not until May 15, 1977 did the Chicago Tribune address that distinction, despite a letter to the editor in 1975 expressing confusion on that very point.[62, 63]

Even more fundamentally, most science writers declined to discuss the philosophical question that arose in Congressional hearings and forms the focus of Dotto and Schiff's final chapter in Ozone War: In an environmental question such as this, who should be expected to bear the burden of proof? As noted earlier, many political decisions must be made without the benefit of complete information. Dotto and Schiff point out, "should neither side be able to gain a clear victory -- then the one who has the burden of proof loses."[64] Should man-made substances be assumed innocent until proven guilty? Or should they have to prove their innocence? To what extent should decisions be based on risk-benefit analyses? Answers to such questions are important: A lack of understanding about them would leave the public without a firm platform from which to address decision makers.

Much of what we have criticized about the reporting of the fluorocarbon debate might be termed "error by omission." Such errors are also apparent in other science journalism, as Susan Cray Borman found through a recent study of science news accuracy in several magazines. Borman notes some of the faults we have found: 21 percent of the articles omitted information about the research methods and results or about the uncertainty of the findings.

Space and time restrictions make it difficult for media to remedy omission errors -- more complete articles would demand more research time and more space, both of which are at a premium on most publications. Borman suggests that

media adopt the policy of publishing fewer science articles, if necessary, to ensure that the important stories receive the attention they deserve.[65] That advice should not be heeded by media wanting to improve current coverage of the fluorocarbon debate, although it might have applied to 1975 fluorocarbon coverage. Some media watchers, including scientists, are calling for both more and longer science articles. John Hayes, for one, contends:

> To the extent the coverage (of the fluorocarbon debate) was exemplary of the way that critical questions of science get reported and discussed in the mass media, it is a latent crisis because we're reaching a situation in which the man on the street isn't able to evaluate scientific components of public policy. The result will be either a terrible backlash against science or a situation in which there is a disconnection between the scientific realities of the world and what most people know about.[66]

Science reporters may not be capable of singlehandedly avoiding that situation. But clearer reports of issues such as ozone depletion by fluorocarbons could bring non-scientists and scientists one step closer to understanding.

FOOTNOTES

[1]Qualitative analysis was made of the coverage in the New York Times, Chicago Tribune and Wall Street Journal. The number of articles printed was quantified for the Los Angeles Times, Christian Science Monitor and London Times, using the Bell and Howell Newspaper Index (Wooster, Ohio Microphoto Division). Bell and Howell was also used for the Chicago Tribune; the New York Times Index and the Wall Street Journal index were used for those papers, respectively.

Qualitative analysis was made of the coverage in Newsweek, Time, the New Yorker, Business Week, Progressive, Readers Digest, The Nation, Fortune. The number of articles was quantified for others, such as U.S. News, Current, Aviation Week, Saturday Review World, Changing Times and Harper's Bazaar. The index search was done in the Reader's Guide to Periodical Literature. Conclusions about "the media" and "science writers" made throughout this paper should be understood as referring only to those outlets noted here.

[2]Hillier Krieghbaum, Science and the Mass Media (New York: New York University Press, 1967, p. 63, quoting a 1957-8 survey done by the National Association of Science Writers and the New York University. He says the survey results appear to remain valid "despite television's advantage during space spectaculars," perhaps "due to their ability to present a smorgasbord of news."

[3]When voting to kill the planned supersonic transport prototypes in 1971, Congress ordered the Department of Transportation to study the likely effects of an SST fleet. The research project, termed the Climatic Impact Assessment Program, took three years, involved 1,000 scientists from ten countries and cost $21 million in direct funds plus about $40 million in indirect government and university contributions. The New York Times magazine termed the study "perhaps the most expensive after the fact technological assessment ever produced in the United States." Lee Edson, "Not with a bang but a Pffffft?" New York Times magazine, Dec. 21, 1975, p. 38.

[4]John Hayes, Indiana University chemistry professor, address to foreign journalists, Indiana Memorial Union, Bloomington, Sept. 28, 1978.

[5]Krieghbaum, p.12.

[6]Peter Farago, Science and the Media (London: Oxford University Press, 1976), p.6.

[7]Ibid., p.3.

[8]Later measurements indicate about one part per four million parts of air are in the atmosphere; most of that is concentrated more than 10 miles above Earth.

[9]Atmospheric physicist James E. McDonald had earlier suggested that water vapor from the proposed SSTs could become a man-made ozone-destroyer. But, perhaps because he was known for espousing such causes as unidentified flying objects, McDonald received little attention.

[10]Herb Wiser, Ph.D., principal science adviser in the Office of Research and Development, Environmental Protection Agency, telephone conversation Nov. 21, 1978.

[11]Lydia Dotto and Harold Schiff, The Ozone War (Garden City, NY: Doubleday & Co., Inc., 1978), p.20.

[12]Paul Brodeur, "Annals of Chemistry (Inert)," The New Yorker, April 17, 1975, pp. 47-50+.

[13]Dotto and Schiff, p.21.

[14]Joel Primack and Frank Von Hippel, Advice and Dissent: Scientists in the Political Arena (New York: Times Mirror, 1974), p. 245.

[15]Rae Goodell, The Visible Scientists (Boston: Little, Brown and Company, 1975, 1977), p. 35.

[16]ABC-TV broadcast a 20-second report on Sept. 10, 1974.

[17]Krieghbaum, p. 10.

[18]Ibid., p. 194.

[19]Farago, p. 73.

[20]Walter Sullivan, "Tests Show Aerosol Gases May Pose Threat to Earth," New York Times, Sept. 26, 1974, p.1.

[21]Dotto and Schiff, p. 21.

[22]Ronald Kotulak, "The Aerosol Can's Threat is No Joke," Chicago Tribune, Sept. 29, 1974, Sec. 2 p.1.

[23]Dotto and Schiff.

[24]Farago terms these two emphases "discovery" and "social," and suggests a third, a synthesis of the two. He terms that "humanistic," and says it takes elements of one and two, putting science in perspective not only with the readers' contemporary life but with past scientific developments, p. 75.

[25]"Doomsday and Aerosol," Chicago Tribune, Oct. 13, 1974, Sec. 2 p.4.

[26]"If in Doubt -- Gamble," New York Times, Nov. 12, 1974, p. 38.

[27]Dotto and Schiff.

[28]John Van Horn, member, Manufacturing Chemists Association, telephone conversation Nov. 21, 1974.

[29]Dotto and Schiff, p. 138.

[30]Ibid., p. 24.

[31]Goodell, p. 8.

[32]Dotto and Schiff, p. 176.

[33]Janet Lowenthal, "Spray Now, Pay Later," The Progressive, Oct. 1975, pp. 43-7.

[34]Tom Alexander, "What we Know -- and Don't know -- About the Ozone Shield," Fortune, August 1975, pp. 184-194.

[35]Lee Edson, "Not with a Bang but a Pffft?"

[36]Richard Ward, public affairs representative for Du Pont, telephone conversation Nov. 21, 1978.

[37]The research Du Pont began in 1972 had been directed here below -- in the troposphere -- and had concluded that fluorocarbons were no hazard because they were inert. Interestingly, as Dotto and Schiff point out, part of Du Pont's current research is aimed at finding fluorocarbon sinks in the troposphere, which would mean fluorocarbons have less effect in the stratosphere. But such findings would contradict the results of Du Pont's 1972 study.

[38]Dotto and Schiff, p. 148.

[39]Primack and Von Hippel, p. 276-7.

[40]Lowenthal, p. 43.

[41]Rowland (Sherry) and Mario J. Molina, letter to the editor, Science, Dec. 12, 1975, pp. 1036, 1038.

[42]But Al Lazrus, the scientist who had taken those measurements, later informed his peers in a "dear colleague" letter that the hydrochloric acid data in his preliminary paper had been wrong due to a calibration error. Dotto and Schiff, p. 250.

[43]Ibid., pp. 267-72.

[44]Harold M. Schmeck Jr., "Scientists Back New Aerosol Curbs To Protect Ozone in Atmosphere," New York Times, Sept. 14, 1976, p. 27 .. continued from p. 1.

[45]Dotto and Schiff, p. 277.

[46]Donald Hunten, Ph.D. and professor of planetary sciences, University of Arizona, telephone conversation Nov. 20, 1978.

[47]Alfonz Forziati, Ph.D., EPA research staff, telephone conversation Nov. 21, 1978.

[48]Ward.

[49]Wiser.

[50]William R. Oates, "Social and Ethical Content in Science Coverage by News Magazines," Journalism Quarterly (50:680-4).

[51]Farago, p. 2.

[52]John Troan, quoted in Krieghbaum, p. 171.

[53]Alexander, in Fortune, for example, quoted atmospheric scientist Michael McElroy who compared ozone's equilibrium to the water level in a bathtub with an open drain and an open water tap. "Obviously, anything that serves to increase the size of the drain would lower the water level. Similarly, any additional supply of nitrogen oxides -- or any other substance capable of destroying ozone -- would increase the rate of ozone depletion, and to some extent decrease the supply." p. 186.

[54]Krieghbaum,.p. 21.

[55]The diagram did change, however, after its first use: it acquired a wavy instead of a uniform depiction of the ozone layer.

[56]Hayes, speech.

[57]Hayes, personal interview.

[58]Dotto and Schiff, p. 237.

[59]Ibid., p. 189.

[60]Goodell, p. 206-7.

[61]Dotto and Schiff, p. 174.

[62]Jon Van, "Ozone: Vital up there, but deadly down here," Chicago Tribune, May 15, 1977, p. 18.

[63]Warren Sahlin, "Voice of the People," Chicago Tribune, June 27, Sec. 2, p. 2, 1975:

SPRING BAY, Ill. -- Will the environmental busybodies clear up something for me? An editorial June 18 says it is quite respectable to worry about the effects of aerosol spray cans, but I am not sure which way to work. Sprays supposedly destroy the ozone, and traffic pollution creates ozone. Should I worry about too much ozone or not enough?

[64]Dotto and Schiff, p. 315.

[65]Susan Cray Borman, "Communication Accuracy in Magazine Science Reporting," Journalism Quarterly, Summer, 1978, pp. 345-6.

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PERIODICALS SURVEYED

1972 to 1978

(Audubon)
(Aviation Week)
(Biological Science)
(Chemistry)
Chicago Tribune
(Christian Science Monitor)
(Changing Times)
(Current)
(Environment)
Fortune
(Harper's Bazaar)
(International Wildlife)
(London Times)
(Los Angeles Times)
The Nation
the New York Times
New York Times magazine
(The New Republic)
The New Yorker
Newsweek
(Physics Today)
(Popular Science)
The Progressive
Readers' Digest
(Saturday Review of Science)
(Saturday Review World)
(Science)
(Science Digest)
(Science News)
(Smithsonian)
(Space World)
Time
(Today's Health)
(U.S. News)
Wall Street Journal

ALSO TELEVISION EVENING NEWS ABSTRACTS:

CBS
ABC
NBC

Items underlined -- all articles found were read and qualitatively critiqued

Items in parentheses -- number of articles published was quantified; no attempt was made to judge their quality.

FLUOROCARBON DEPLETION THEORIES -- TIMELINE OF EVENTS

1970 -- James E. Lovelock detect fluorocarbons in atmosphere
1973 -- F. Sherwood Rowland and Mario Molina begin fluorocarbon research

1974
July -- Rowland and Molina work published, Nature
Sept.-- American Chemical Society at Atlanta -- Rowland speaks, holds news conference
27 -- Science publishes Ralph Cicerone work from University of Michigan.
-- National Academy of Science committee headed by Donald M. Hunten to assess fluorocarbon theory (recommends further study)
Nov. -- National Resources Defense Council (NRDC) seeks ban from Consumer Product Safety Commission (CPSC); press conference held
Dec. -- House Committee on Interstate and Foreign Commerce, Public Health and Environment Subcommittee hearings chaired by Paul G. Rogers (D-Fl) Consider bill to amend Clean Air Act, calling for a NAS study and an EPA ban if further research confirms theories.

1975
Jan. -- Results of three-year Climatic Impact Assessment Program announced. Program was ordered by Congress in 1970, and budgeted for $20 million under the Department of Transportation. Investigated effects of nitrogen-oxide and sulfur dioxide emissions from SSTs.
Feb. -- Fourteen-agency task force on Inadvertent Modification of the Stratosphere (IMOS) formed at instigation of Russell W. Peterson, chairman of the Council on Environmental Quality, and H. Guyford Stever, chairman of the Federal Council on Science and Technology. Chaired by Warren R. Muir.
-- Bills introduced in House and Senate which would urge action toward a ban.
-- IMOS hearing -- McElroy notes use of bromine as a war tool to deplete ozone.
Mar. -- National Research Council report on cancer risk from decrease in ozone
May -- NRDC to take CPSC to court for denying petition
-- NOAA study notes ozone fluctuation -- a downturn in the early 1970s, preceded by an upswing
June -- IMOS report released. Recommends labels on products containing fluorocarbons, suggests agencies work toward a ban, and cancel plans if research results change.
-- Oregon governor signs ban on aerosol sprays, effective 1977.
30 -- Du Pont places advertisement in various papers; first of a series
July -- CPSC rejects NRDC petition three to two.
16 - EPA begins to study likely effects of possible aerosol ban on economy
Sept.-- SenateCommittee on Aeronautical and Space Sciences, Subcommittee on the Upper Atmosphere begins holding hearings (continue through early 1976)
Oct. -- Industry cites volcano as possible test of depletion theories (If Alaskan crater erupts, will throw Chlorine from sea water into the atmosphere)
Nov. -- International conference sponsored by National Institutes of Health, Durham, NC
-- Explorer 55 satellite launched
Dec. -- OH + HCl reaction found inconsequential; fluorocarbon breakdown found to be no slower in frigid temperatures than here below -- findings contradicted theories of circumstances thought to mitigate harm from fluorocarbons.
-- First Chemical Congress of the North American Continent, Mexico City
-- EPA report on economic impact of ban released, done by Arthur D. Little
12 -- Rowland letter published in Science as reply to second in series of Du Pont ads.
-- NRDC and 10 states urge CPSC to ban fluorocarbons

1976

Jan. -- New York state to require warning labels
-- volcano erupts

Apr. -- IMOS reports nitrogen fertalizers, brominated compounds, chlorinated compounds, dust particles in the stratosphere, carbon monoxide and nitric oxides do not present immediate danger, but research on them should continue

May --- France, Breat Britain and the U.S. sign Tripartite Agreement to monitor ozone
-- $ClO + NO_2$ reaction producing $ClONO_2$ (chlorine nitrate) may be more stable than previously thought, meaning ozone might not be depleted as fast by SSTs and fluorocarbons (later research showed this reaction quite unimportant)

Sept.-- National Academy of Sciences study indicates some action is necessary against the use of fluorocarbons, but a delay of up to two years would be tolerable

16 -- World Meteorological Organization to study uncertainties pointed out in Academy report.

Oct. -- FDA proposes phase-out of non-essential uses of fluorocarbons

Nov. -- CPSC votes five to zero to grant NRDC petition to begin regulatory action against fluorocarbon propellants

24 -- FDA proposes warning labels, CPSC moves to regulate aerosols

Dec. -- Michigan legislature bans fluorocarbons in aerosols, beginning in 1979

1977

Jan. -- California aerosol cans to carry warning if propelled by fluorocarbons

Feb. -- sand may aid atmospheric fluorocarbon destruction, National Bureau of Standards research indicates

Mar. -- U.N. Environmental Program holds international conference in Washington D.C. Little support shown for early regulation in other countries.

Apr. -- FDA and EPA draft regulations to ban "nonessential" uses of fluorocarbons in aerosols. Will issue regulations April 26; labels required by Oct. 31.

May -- FDA, CPSC propose 1979 ban.
-- Robert H. Abplanalp announces invention of aquasol, alternative to fluorocarbons as an aerosol propellant

June -- $NO + O_2H$ reaction producing $NO_2 + OH$ occurs ten to forty times faster than previously estimated, meaning SST is half as destructive than believed, but fluorocarbons destroy 30 to 35 percent more than thought. Also, hydroxyl and perhydroxyl are reacting at one-fifth to one-tenth faster than previously thought, which could increase ozone depletion. Reports made at American Geophysical Union

1978

Jan. -- Sweden becomes first country to ban fluorocarbons in most aerosol sprays, effective Jan. 1979.
-- Methylchloroform may deplete ozone, according to York University research in Science. Theory assumes methylchloroform can survive about eight years in the lower atmosphere

Mar. -- EPA, FDA, CPSC announce ban, effective Oct. 15, on manufacture of nearly all aerosols using fluorocarbons (packaging ban Dec. 15; shipping ban April 15).

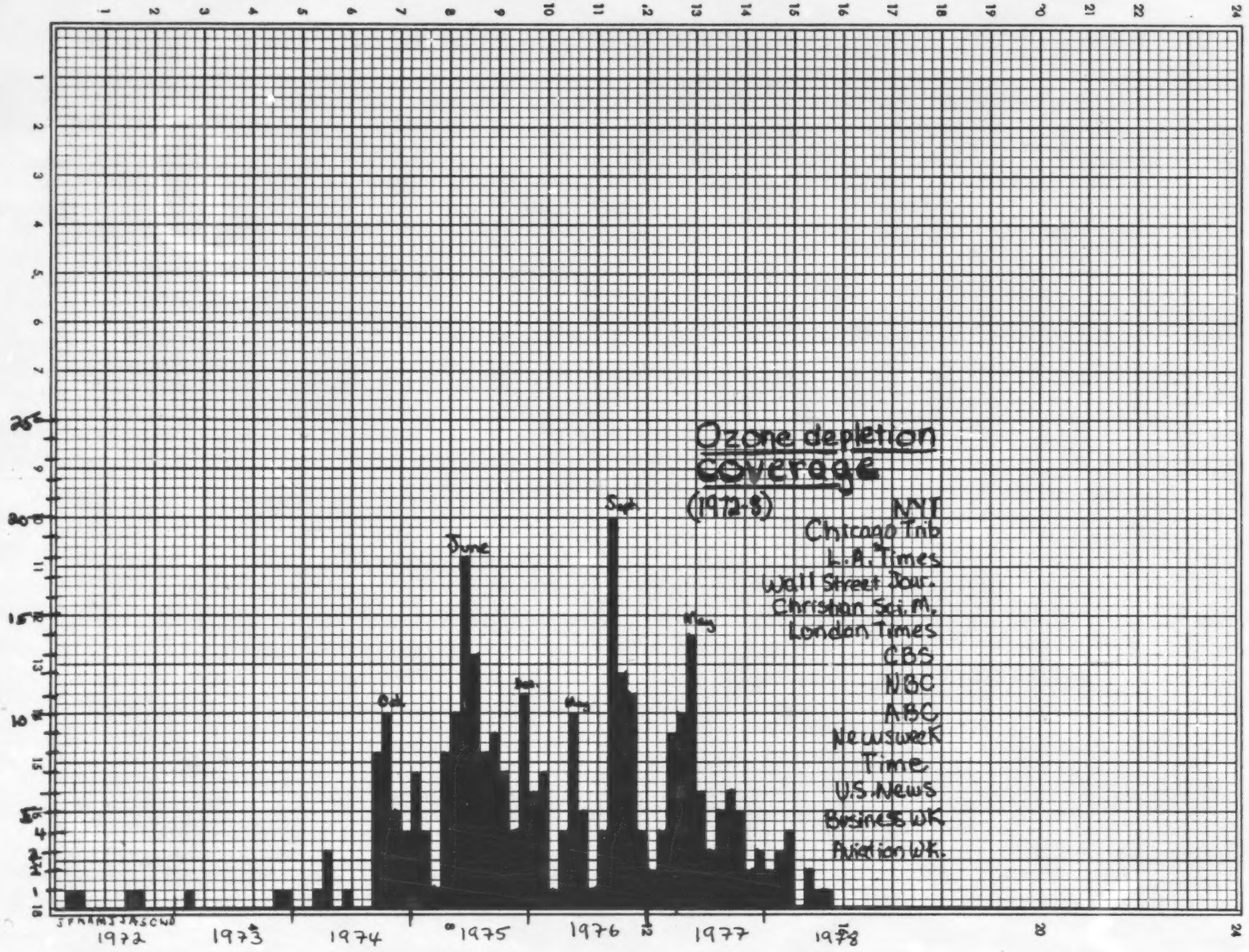
June -- Royal Society of Britain releases study group report, "Pollution in the Atmosphere" saying no immediate regulatory action is necessary

July -- NASA sponsors workshop, Boulder, Col.

Nov. -- U.N. Environmental Program meeting in Bonn

Dec. -- American Geophysical Union fall meeting
-- International regulators' meeting in Munich

1979 -- National Academy of Sciences ozone review and Rand study of economic effects of further fluorocarbon regulation due.


Ozone depletion coverage
(1972-8)
NYT
Chicago Trib
L.A. Times
Wall Street Jour.
Christian Sci. M.
London Times
CBS
NBC
ABC
Newsweek
Time
U.S. News
Business Wk
Aviation Wk.
June
Sept
May
Oct
Jan
April
J F M A M J J A S O N D
1972
1973
1974
1975
1976
1977
1978